

Editorial Comment

Real-Time Two-Dimensional Doppler Flow Imaging: A Word of Caution*

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During the past few years, several major technologic advances have significantly enhanced our ability to evaluate cardiac function at macroscopic, microscopic and metabolic levels. The newly available techniques include digital subtraction angiography, positron emission tomography, nuclear magnetic resonance imaging, high speed computed tomography and real-time two-dimensional Doppler (color-coded) flow imaging. Because use of these new methods results in greater health care costs that eventually must be paid by the patient, careful consideration must be given to their potential value not only to academic institutions, but also to the individual patient.

The study by Miyatake et al. (1) in this issue of the Journal evaluates the semiquantification of the severity of mitral regurgitation by Doppler flow imaging, a new non-invasive technique that allows simultaneous viewing of color-coded pulsed Doppler flow superimposed on a real-time two-dimensional echocardiogram. The Doppler signal is presented in colors that vary with both the direction of blood flow (shades of orange-red indicate blood flow toward the transducer and shades of blue indicate flow away from the transducer) and the velocity of blood flow (inability to differentiate flows with a velocity greater than 60 cm/s in the beam direction, or "aliasing," results in a multicolored mosaic pattern) (2,3). Preliminary studies (4) utilizing this technique have shown favorable correlations with routine methods for detecting valvular regurgitation. The potential applications of Doppler flow imaging include evaluation of the presence and severity of valvular regurgitation, identification of intracardiac shunts (by determination of flow direction and relative volume) and assessment of the response of abnormal blood flow to pharmacologic or surgical intervention (5-7). For example, mitral regurgitation would

appear as a systolic stream of bluish color flowing retrograde from the left ventricle into the left atrium covering an area corresponding to the reflux volume, repeatedly seen with each ventricular systolic contraction and viewed simultaneously with the real-time echocardiographic image. Despite the limitation of aliasing at higher velocities, flow imaging facilitates localization of the highest velocity jet of stenotic lesions, which can then be quantified by continuous wave Doppler imaging. Therefore, real-time Doppler flow imaging provides information that is unavailable by other noninvasive techniques and provides it faster. Color-coded Doppler imaging is a major breakthrough in the diagnosis and management of congenital heart disease. Cardiac shunts can be localized and semiquantified, thereby expediting diagnosis in the critically ill neonate, and potentially replacing cardiac catheterization in certain situations.

Advantages. The report by Miyatake et al. (1) is the first to formally present a method for semiquantifying Doppler flow imaging. With current Doppler methods, meticulous, time-consuming interrogation of the appropriate chamber (that is, the left atrium in mitral regurgitation) can determine the depth of regurgitant flow, which has been correlated with severity of regurgitation (8). However, depending on the anatomic nature of the valvular lesion, a minimal reflux jet may be narrow but penetrate deep into the left atrium (interpreted as severe mitral regurgitation), whereas a large regurgitant volume may be directed at an off angle while not extending too far posteriorly (interpreted as minimal regurgitation) (9). However, by visualizing the Doppler flow map in real time, the entire depth and breadth of the regurgitant flow can be measured by planimetry and its severity estimated by comparing its size with that of the entire chamber (ratio of the area of regurgitant volume, as demarcated in color, to the area of the entire left atrium yields a regurgitant fraction). The technique may prove particularly valuable in sequential assessment of patients with aortic or mitral regurgitation or in determining the contribution of valvular regurgitation to ventricular dysfunction. In addition, the differentiation of acute mitral regurgitation from ventricular septal defect can be expedited in patients with hypotension after myocardial infarction. Ventriculograms during cardiac catheterization may be planned more judiciously or avoided altogether in patients too ill to tolerate the dye load. Also, the severity of tricuspid regurgitation, frequently an incidental finding by pulsed Doppler echocardiography, could be estimated noninvasively. Potentially, intracardiac shunt flow could be semiquantified by the same area method currently described for mitral regurgitation. Clearly, in experienced hands, Doppler flow imaging is much faster than present noninvasive techniques such as the nuclear regurgitant index or pulsed Doppler method for estimation of valvular incompetency.

*Editorials published in *Journal of the American College of Cardiology* reflect the views of the authors and do not necessarily represent the views of JACC or the American College of Cardiology.

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Limitations. There are, however, several limitations of real-time two-dimensional Doppler flow imaging. The image quality of the two-dimensional echocardiogram may not be as good as that obtained with a dedicated two-dimensional echocardiographic machine. The new sophisticated technology may, in fact, demand greater skill than is demanded by routine Doppler echocardiography. Minimal alterations in transducer angulation can dramatically affect the extent of observed regurgitant flow as the sampling volume moves in and out of the plane of the jet stream of blood flow. In addition, subtle gain-setting modifications can create artifacts, thereby causing a minimal lesion to appear to be a severely regurgitant valve, as demonstrated by Miyatake et al. (1) (their Fig. 1). As several studies have shown (10), Doppler imaging may be overly sensitive in detecting minimal regurgitant flows of questionable significance. Will therapy be guided more by the Doppler imaging-defined severity of valvular insufficiency than by clinical criteria? It is hoped that these issues will be answered by future studies.

The study by Miyatake et al. (1) demonstrates some of the limitations of the method. One hundred nine patients who were studied by contrast ventriculography and color-flow Doppler imaging were evaluated (77 with angiographically proved mitral regurgitation). Although the performer of the ventriculogram was blinded to the echocardiographic findings, the echocardiograms were not performed or interpreted blinded to physical examination or ventriculography, potentially introducing study bias. Although the majority of the 11 patients with false negative results by the Doppler method had mild regurgitation, lesions were missed, even in this careful study. In some patients the severity of regurgitation was overestimated. The study would have been more interesting if the authors had initially attempted to estimate the degree of regurgitation by routine pulsed Doppler imaging and then by the new flow imaging technique and compared the time required and accuracy of each method. Furthermore, the authors present two scoring methods of the regurgitant volume: one based on greatest depth into the left atrium, the other on total area volume measured by planimetry. A comparison of these methods in each individual patient would have been valuable. However, the study demonstrates that color-coded real-time Doppler flow imaging can estimate severity of valvular regurgitation fairly accurately.

Conclusions. Real-time color-coded Doppler flow imaging is a new, exciting, noninvasive technique to visualize and semiquantify blood flow abnormalities that has applications for both adult and pediatric cardiology. However, caution is advised because of the potential for both under- and overestimation of abnormal flow patterns. Greater technical and interpretive skill is required than for routine pulsed Doppler studies. Moreover, application of this and other sophisticated technologies should not supplant clinical judgment but should add another dimension to the growing array of diagnostic techniques available to the clinician. The future role of each new method in routine patient care (as compared with academic investigations) awaits further definition by careful research studies.

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